LITHIC FRAGMENTS OF THE CAYLEY PLAINS. R. L. Korotev, K. M. Rockow, B. L. Jolliff, and L. A. Haskin, Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130. (rlk@levee.wustl.edu)

We have initiated a study of small lithic fragments from the regolith of the Cayley plains at the Apollo 16 site in order to understand the nature of this widespread geologic unit. The Cayley plains are usually thought to be an ejecta deposit, probably from the Imbrium impact [1–3]. Although numerous rocks were collected from the Cayley plains during the Apollo 16 mission, many questions remain about which rock types are characteristic of the plains as well as their relative abundances and origins. Rocks in the ejecta of North Ray crater (NRC) have been thoroughly studied [e.g., 4,5], but no such systematic study has been made of the rocks of the Cayley plains. Some NRC materials are thought to be samples of the Descartes Formation, probably representing Nectaris ejecta, excavated from beneath the Cayley Formation by the NRC impactor [4]. Still-unanswered questions include what fraction of Descartes material occurs in the Cayley plains and what are the relative abundances of pre-Nectaris materials, Nectaris ejecta, and primary Imbrium ejecta. These questions are important to understanding how material was redistributed by basin-forming impacts.

Thus far, using instrumental neutron activation analysis and binocular microscope examination, we have studied 347 lithic particles from the 2–4 mm grain-size fraction (6xxx3) of 21 regolith samples (6xxx0) from each of the central and southern sampling stations of the Apollo 16 site (stations LM, 1, 2, 4, 5, 6, 8, & 9). In selecting particles to study, we sought representative samples of all lithologies distinguishable microscopically. Because we were most interested in the more primary lithologies, however, our sampling discriminated against (with respect to their relative abundance) particles that were multilithologic on a gross scale (e.g., dimict breccias, particles with glass coatings) and glassy breccias (including agglutinates and regolith breccias), although some particles of these types were included. Also, our suite underrepresents one common component of the Cayley regolith: highly feldspathic particles dominated by one or a few grains of plagioclase [6,7].

Results: About 38% of the particles, essentially all those with >8 µg/g Sm (Fig. 1), are moderately mafic, crystalline impact-melt breccias (IMBs) with concentrations of incompatible elements 0.3–1.8× those in KREEP basalt, *i.e.*, they are "VHA" and "LKFM basalts" [8]. This proportion (38%) compares with ~30% estimated in mature soil (<1-mm fines) from mass-balance constraints [9] (the difference probably reflects our sampling bias against highly feldspathic particles). About 20% of the MIMBs (mafic IMBs) are of compositional group 1 (*i.e.*, "poikilitic" or "LKFM;" >16 µg/g Sm) and the rest are of compositional group 2 (*i.e.*, "VHA;" 8–16 µg/g Sm). About 50 group-2 particles are compositionally very similar to each other and to the melt-breccia phase of the Apollo 16 dimict breccias (group 2DB of [8]). (The dimict breccias consist of a MIMB phase intermingled with a highly feldspathic anorthosite phase [10].) Particles of this composition were found at all stations. Only about 13 particles are compositionally similar to the group-2 MIMBs characteristic of NRC ejecta (group 2NR of [8]). Three coarse-grained particles are very similar to previously unique sample 64815 [8], suggesting that the four samples may represent yet another compositional group of Apollo 16 MIMB, which we tentatively designate group 1S (high Sc). One MIMB particle is similar to melt breccias from Apollo 14; it is very rich in incompatible elements (e.g., 41 µg/g Sm) with high Th/Sm (0.46, compared to 0.35 ± 0.02 for Apollo 16 MIMBs). Based on composition and texture, only 5–7 (<2%) particles correspond to feldspathic group 3 IMBs.

Nearly all particles with <4 µg/g Sc are anorthosites (>90% plagioclase); most of these appear to be breccias although some are mostly glass. Many of the most Sc-poor particles are crystalline plagioclase. Among the anorthosites are ~6 that are probably troctolitic anorthosites, based on their high Cr/Sc ratios (>100). Composition alone cannot be used to distinguish among the numerous fragments (generically, noritic anorthosites, ~4–12 µg/g Sc) that are compositionally similar to feldspathic fragmental breccias, granulitic breccias, group-4 IMBs, and regolith breccias. Most particles plotting between the Sm-rich MIMBs and the Sm-poor feldspathic rocks in Fig. 1 are probably polymict breccias and glasses constructed from both types of material.

Three particles appear to be either low-Ti mare basalts or breccias derived from mare basalt. Three others are gabbronorites; one of these is a sodic ferrogabbro (high Na, Ba, Eu) [11] and another is unusually rich in Cs (5.4 µg/g).

Two simple observations with far-reaching implications: (1) The proportion of KREEP-bearing, mafic impact-melt breccias in the regolith of the Cayley plains at the Apollo 16 site is high, at least 30%. (2) The range of compositions of the lithologies of which the soil of the Cayley plains is composed is very great compared to the small range observed among all samples of mature soil (Fig. 1). In particular, the ratio of MIMBs (basin-era products) to feldspathic lithologies (representing prebasin crust) must be essentially constant in mature soil across the Apollo 16 site. By comparison to the Apollos 15 and 17 sites, where soil compositions vary substantially over 100's of meters [12,13], the high degree of homogenization of the Cayley soils cannot have been achieved by post-basin impacts. The component lithologies of the Cayley plains must have been well mixed on a gross scale by the event that formed the plains, presumably a basin-forming impact.

If the MIMBs were formed in regional craters or in Nectaris and thus were a component of the pre-Imbrium local substrate, then (1) there are few candidates among the Apollo 16 samples for Imbrium impact melt (perhaps, the one Apollo-14-like breccia encountered here) and either (2a) there is little primary Imbrium ejecta in the Apollo 16 regolith or (2b) the primary Imbrium ejecta must be more feldspathic and poorer in KREEP than the pre-Imbrium substrate at the Apollo 16 site!

It is more likely that all Apollo 16 MIMBs are primary Imbrium ejecta and, consequently, that (1) at least 30% of

the Cayley plains at the Apollo 16 site is primary Imbrium ejecta and either (2a) all the Apollo 16 MIMBs are Imbrium impact melt and the Imbrium impact produced units of melt breccia of different compositions (groups 1M, 2DB, etc.) and delivered several of these units to the Apollo 16 site or (2b) the Apollo 16 MIMBs are from pre-Imbrium craters in the vicinity of the Imbrium basin, these craters were formed in a geochemical province in which mafic, KREEP-bearing material dominated near the surface [14], and Imbrium redistributed the MIMBs as primary ejecta.

Both lithophile- and siderophile-element elements argue that the different compositional groups of Apollo 16 MIMBs (supergroups 1 and 2) are all related, making it highly unlikely that they are products of two or more basin forming impacts, or that one group is from a basin and others are from local craters [8].

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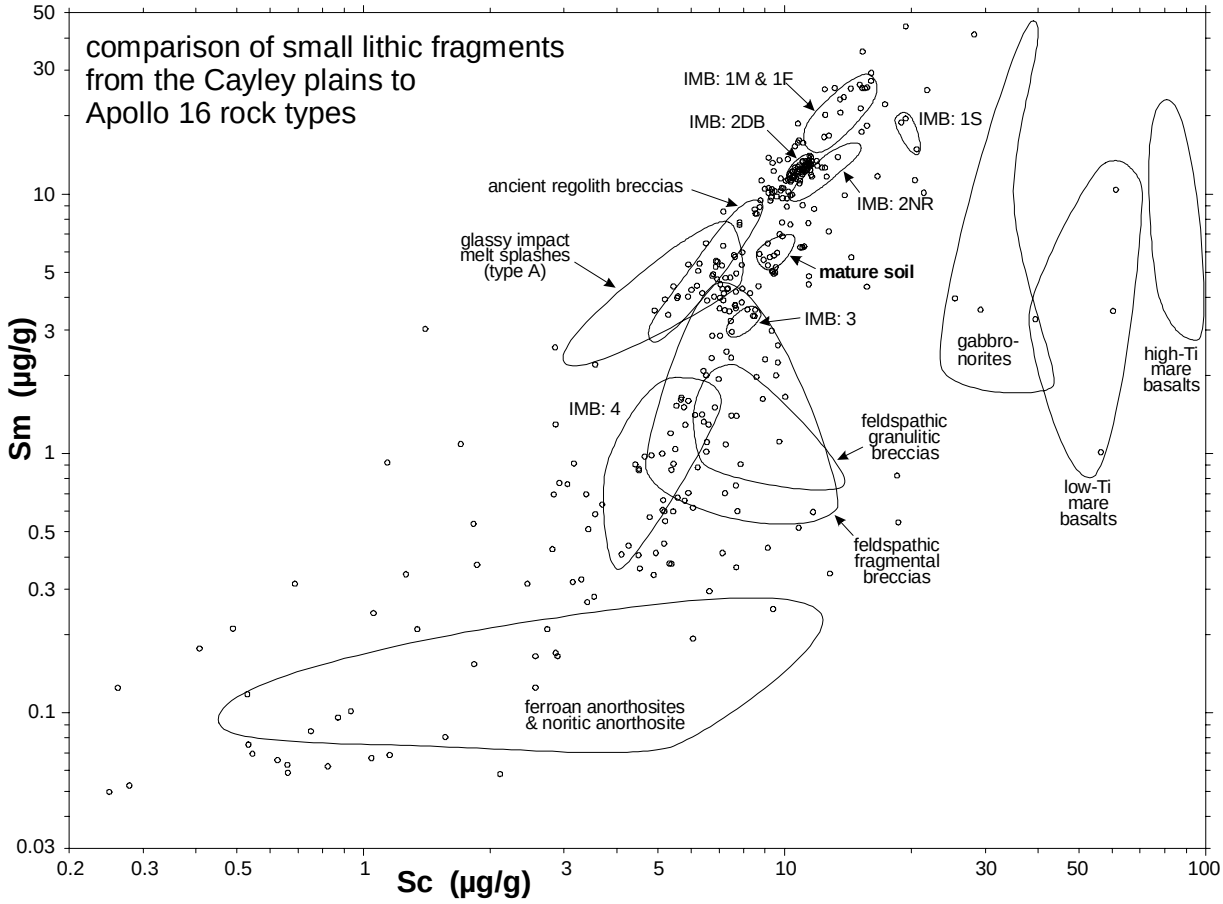

Fig. 1. Sc-Sm classi*fication diagram for the 347 small (2–4 mm) lithic fragments studied here. The fields are based on large rocks from Apollo 16, except for those of the mare basalts, which represent all known types of mare basalt, and that for group-1S IMBs (impact-melt breccias), which encloses 3 fragments with compositions very similar to unique sample 64815 [8]. The group-1M and -1F IMBs and the ferroan anorthosites are the only Apollo 16 rock types that are so coarse grained that a 2–4-mm fragment may be grossly unrepresentative of the larger rock from which it came; this accounts in part for points that lie outside, but near the field for these two lithologies. The most Sc-poor particles are virtually pure plagioclase. The field for impact melt splashes (IMS) includes some ~2-mm glass spheroids similar in composition to the type-A IMS studied by Morris *et al*. [15], which are believed to have formed in the South Ray crater impact. For comparison, the range of all 22 samples of mature soil (<1 mm fines) is shown. Some samples plotting in and near this field are probably regolith breccias.